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Predicting shape fixity and recovery of shape memory polymers

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ABSTRACT

Previous experimental observations have demonstrated that the polymer shape fixity and recovery are strongly dependent on the programming and recovery conditions. In this study, we provide a simple but unified theory to unravel this dependence. Analytical solution to a one-dimensional multibranch constitutive model is derived to facilitate the discussions. Generally, the polymer shape fixity is shown to decrease as the programming temperature decreases, and a lower shape fix ratio would lead to a higher shape recovery rate. A material timing frame is then defined based on the time temperature superposition (TTSP) to characterize the rheological state of SMPs. Parametric studies revealed that the same rheological state can be achieved by different programming methods and leads to the same shape fixity and shape recovery rate if the subsequent recovery condition is identical. Under different recovery temperatures, SMPs with the same shape fixity can have different recovery curves, which are also shown to follow TTSP when shifting them into a master curve at the reference temperature. The results presented in this study help to clarify the complicate dependence of polymer SM effect on the thermal history and predict the recovery behavior at different recovery conditions.